CLAIMS

What is claimed is:

1. An electro-active sensor for detecting electro-active species in solution, comprising:

a nonconductive platform, the nonconductive platform having a first side and a second side;

a first electrode set attached with a first side of a nonconductive platform, wherein the first electrode set further comprises:

a first conductive via passing through the nonconductive platform from the first side to the second side;

a first electrode attached with the first conductive via on the first side, where the first electrode serves as a first working electrode;

a second conductive via passing through the nonconductive platform from the first side to the second side;

a second electrode attached with the second conductive via on the first side, where the second electrode serves as a first reference electrode;

a third conductive via passing through the nonconductive platform from the first side to the second side; and

a third electrode attached with the third conductive via on the first side, where the third electrode serves as an first auxiliary electrode, whereby the working electrode, the reference electrode, and the auxiliary electrode serve as a electrochemical cell that may be utilized to detect the electro-active species in the solution.

2. An electro-active sensor as set forth in Claim 1, wherein the electro-active sensor further comprises a plurality of electrode sets.

3. An electro-active sensor as set forth in Claim 2, wherein the electro-active sensor further comprises electrical connectors connected with the vias on the second side of the nonconductive platform, whereby the electrical connectors may be connected with a monitoring apparatus, allowing for monitoring of the electro-active species in the solution.

4. An electro-active sensor as set forth in Claim 3, wherein the nonconductive platform is constructed of a material selected from a group consisting of ceramic and glass.

5. An electro-active sensor as set forth in Claim 4, wherein the electrodes are all formed in a substantially co-planar manner.

6. An electro-active sensor as set forth in Claim 5, wherein the electrical connectors are substantially co-planar and a plane of the electrical connectors is parallel with respect to a plane of the nonconductive platform.

7. An electro-active sensor as set forth in Claim 6, wherein at least a portion of each electrode in the electrode set is formed in a shape selected from a group consisting of a ring and a disk.

8. An electro-active sensor as set forth in Claim 7, wherein each electrode set is formed such that the electrodes in the electrode set are concentric.

9. An electro-active sensor as set forth in Claim 8, wherein the reference electrode surrounds the working electrode, and the auxiliary electrode surrounds the reference electrode.

10. An electro-active sensor as set forth in Claim 9, wherein the first auxiliary electrode from the first electrode set is connected with a second auxiliary electrode from a second electrode set.

11. An electro-active sensor as set forth in Claim 10, wherein the first and second auxiliary electrodes are connected with a common ground.

12. An electro-active sensor as set forth in Claim 11, wherein the electro-active sensor further comprises a biofilm attached with the first side of the nonconductive platform.

13. An electro-active sensor as set forth in Claim 12, wherein the electro-active sensor further comprises an Ion Selective Sensor attached with the first side of the nonconductive platform.

14. An electro-active sensor as set forth in Claim 13, wherein the Ion Selective Sensor is a pH sensor.

15. An electro-active sensor as set forth in Claim 14, wherein the electro-active sensor further comprises a four-terminal conductivity sensor attached with the first side of the nonconductive platform, thereby allowing for a measurement of a conductivity of the solution.

16. An electro-active sensor as set forth in Claim 15, wherein the electro-active sensor further comprises a two-terminal heater attached with the nonconductive platform, thereby allowing the electro-active sensor to be heated to varying temperatures.

17. An electro-active sensor as set forth in Claim 16, wherein the electro-active sensor further comprises a two-terminal temperature sensor attached with the nonconductive platform, thereby allowing for monitoring of a temperature of the electro-active sensor.

18. An electro-active sensor as set forth in Claim 17, wherein the electro-active sensor further comprises circuitry attached with the electrical connectors, the circuitry further comprising:

a potentiostat circuit portion attached with an electrochemical cell, the electrochemical cell comprising a grounded auxiliary electrode, a reference electrode, and a working electrode, whereby when activated, the potentiostat circuit portion forces a voltage between the working electrode and the reference electrode;

a feedback circuit connected with the potentiostat circuit portion, whereby when the potentiostat circuit portion is activated, the feedback circuit adjusts a current though the electrochemical cell accordingly;

a galvanostat circuit portion attached with the electrochemical cell, whereby the galvanostat circuit portion forces a current through the electrochemical cell and when the galvanostat circuit portion is activated the feedback circuit adjusts a voltage between the working electrode and the reference electrode; and

a switch circuit connected with the potentiostat circuit portion and galvanostat circuit portion, allowing for the activation of the potentiostat or galvanostat circuit portion.

19. An electro-active sensor as set forth in Claim 2, wherein the first auxiliary electrode from the first electrode set is connected with a second auxiliary electrode from a second electrode set.

20. An electro-active sensor as set forth in Claim 2, wherein the first and second auxiliary electrodes are connected with a common ground.

21. An electro-active sensor as set forth in Claim 1, wherein the electro-active sensor further comprises electrical connectors connected with the vias on the second side of the nonconductive platform, whereby the electrical connectors may be connected with a monitoring apparatus, allowing for monitoring of the electro-active species in the solution.

22. An electro-active sensor as set forth in Claim 21, wherein the electrical connectors are substantially co-planar and a plane of the electrical connectors is parallel with respect to a plane of the nonconductive platform.

23. An electro-active sensor as set forth in Claim 1, wherein the nonconductive platform is constructed of a material selected from a group consisting of ceramic and glass.

24. An electro-active sensor as set forth in Claim 1, wherein the electrodes are all formed in a substantially co-planar manner.

25. An electro-active sensor as set forth in Claim 1, wherein at least a portion of each electrode in the electrode set is formed in a shape selected from a group consisting of a ring and a disk.

26. An electro-active sensor as set forth in Claim 1, wherein each electrode set is formed such that the electrodes in the electrode set are concentric.

27. An electro-active sensor as set forth in Claim 1, wherein the reference electrode surrounds the working electrode, and the auxiliary electrode surrounds the reference electrode.

28. An electro-active sensor as set forth in Claim 1, wherein the electro-active sensor further comprises a biofilm attached with the first side of the nonconductive platform.

29. An electro-active sensor as set forth in Claim 1, wherein the electro-active sensor further comprises an Ion Selective Sensor attached with the first side of the nonconductive platform.

30. An electro-active sensor as set forth in Claim 29, wherein the Ion Selective Sensor is a pH sensor.

31. An electro-active sensor as set forth in Claim 1, wherein the electro-active sensor further comprises a four-terminal conductivity sensor attached with the first side of the nonconductive platform, thereby allowing for a measurement of a conductivity of the solution.

32. An electro-active sensor as set forth in Claim 1, wherein the electro-active sensor further comprises a two-terminal heater attached with the nonconductive platform, thereby allowing the electro-active sensor to be heated to varying temperatures.

33. An electro-active sensor as set forth in Claim 1, wherein the electro-active sensor further comprises a two-terminal temperature sensor attached with the nonconductive platform, thereby allowing for monitoring of a temperature of the electro-active sensor.

34. An electro-active sensor as set forth in Claim 1, wherein the electro-active sensor further comprises circuitry attached with the electrical connectors, the circuitry further comprising:

a potentiostat circuit portion attached with an electrochemical cell, the electrochemical cell comprising a grounded auxiliary electrode, a reference electrode, and a working electrode, whereby when activated, the potentiostat circuit portion forces a voltage between the working electrode and the reference electrode;

a feedback circuit connected with the potentiostat circuit portion, whereby when the potentiostat circuit portion is activated, the feedback circuit adjusts a current though the electrochemical cell accordingly;

a galvanostat circuit portion attached with the electrochemical cell, whereby the galvanostat circuit portion forces a current through the electrochemical cell and when the galvanostat circuit portion is activated the feedback circuit adjusts a voltage between the working electrode and the reference electrode; and

a switch circuit connected with the potentiostat circuit portion and galvanostat circuit portion, allowing for the activation of the potentiostat or galvanostat circuit portion.

35. A method for constructing an electro-active sensor for detecting electro-active species in solution, the method comprising acts of:

forming a first electrode set on a first side of a nonconductive platform, wherein the act of forming the first electrode set further comprises acts of:

forming a first electrode on a first side of a nonconductive platform, the first electrode serving as a working electrode;

forming a first via from the first side to a second side of the nonconductive platform, wherein the first via is attached with the first electrode;

forming a second electrode on the first side of the nonconductive platform, the second electrode serving as a reference electrode;

forming a second via from the first side to the second side of the nonconductive platform, wherein the second via is attached with the second electrode;

forming a third electrode on the first side of the nonconductive platform, the third electrode serving as an auxiliary electrode; and

forming a third via from the first side to the second side of the nonconductive platform, wherein the third via is attached with the third electrode, whereby if a solution is placed on the first side of the nonconductive platform, the working electrode, the reference electrode and the auxiliary electrode may be utilized to detect an electro-active species in the solution.

36. A method for constructing an electro-active sensor as set forth in Claim 35, the method further comprising an act of forming a second electrode set on the first side of the nonconductive platform.

37. A method for constructing an electro-active sensor as set forth in Claim 36, the method further comprising an act of forming electrical connectors attached with the vias on the second side of the nonconductive platform, whereby the electrical connectors may be connected with a monitoring apparatus, allowing for detection of the electro-active species in the solution.

38. A method for constructing an electro-active sensor as set forth in Claim 37, wherein the act of forming an electrode on the first side of the nonconductive platform further comprises acts of:

depositing a conductive material on the first side of the nonconductive platform; and

curing the electrically conductive material to affix the conductive material to the nonconductive platform.

39. A method for constructing an electro-active sensor as set forth in Claim 38, wherein the act of forming a via from the first side to the second side of the nonconductive platform further comprises acts of:

forming a via through the nonconductive platform from the first side to the second side of the nonconductive platform;

depositing a conductive material over the via;

creating an electrically conductive via by drawing the conductive material through the via; and

curing the electrically conductive material to affix the conductive material with the first side of the nonconductive platform, with the second side of the nonconductive platform, and with the walls of the via, thereby creating the via.

40. A method for constructing an electro-active sensor as set forth in Claim 39, wherein the act of forming electrical connectors attached with the vias further comprises acts of:

depositing a conductive material on the second side of the nonconductive platform, such that the material is in contact with the vias;

curing the conductive material to affix the conductive material with both the second side of the nonconductive platform and with the vias.

41. A method for constructing an electro-active sensor as set forth in Claim 40, wherein the act of forming an electrode on the first side of the nonconductive platform further comprises an act of selecting a non-conductive platform constructed of a material selected from a group consisting of ceramic and glass.

42. A method for constructing an electro-active sensor as set forth in Claim 41, wherein in the act of forming the first electrode set on the first side of the nonconductive platform, the electrodes are formed such that they are substantially planar.

43. A method for constructing an electro-active sensor as set forth in Claim 42, wherein in the act of forming electrical connectors attached with the vias on the second side of the nonconductive platform, the electrical connectors are formed such that they are substantially planar, with a plane of the electrical connectors being parallel with a plane of the nonconductive platform.

44. A method for constructing an electro-active sensor as set forth in Claim 43, wherein in the act of forming the electrode sets, at least a portion of each electrode in the electrode set is formed in a shape selected from a group consisting of a ring and a disk.

45. A method for constructing an electro-active sensor as set forth in Claim 44, wherein in the acts of forming the electrode sets, each electrode in the electrode sets are formed such that the electrodes are concentric.

46. A method for constructing an electro-active sensor as set forth in Claim 45, wherein in the acts of forming the electrode sets, the reference electrode is formed

such that it surrounds the working electrode, and the auxiliary electrode is formed such that it surrounds the reference electrode.

47. A method for constructing an electro-active sensor as set forth in Claim 46, wherein in the acts of forming the second electrode set on the first side of the nonconductive platform, a second auxiliary electrode from the second electrode set is formed such that it is connected with the first auxiliary electrode from the first electrode set.

48. A method for constructing an electro-active sensor as set forth in Claim 47, wherein the first and second auxiliary electrodes are formed such that they are connected with a common ground.

49. A method for constructing an electro-active sensor as set forth in Claim 48, wherein the method further comprises an act of attaching a biofilm on the first side of the nonconductive platform.

50. A method for constructing an electro-active sensor as set forth in Claim 49, wherein the method further comprises an act of forming an Ion Selective Sensor on the first side of the nonconductive platform.

51. A method for constructing an electro-active sensor as set forth in Claim 50, wherein in the act of forming an Ion Selective Sensor on the first side of the nonconductive platform, the Ion Selective Sensor is a pH sensor.

52. A method for constructing an electro-active sensor as set forth in Claim 51, wherein the method further comprises an act of forming a four-terminal

conductivity sensor on the first side of the nonconductive platform, thereby allowing for measurement of conductivity of the solution.

53. A method for constructing an electro-active sensor as set forth in Claim 52, wherein the method further comprises an act of forming two-terminal heater on the second side of the nonconductive platform, thereby allowing the electro-active sensor to be heated to varying temperatures.

54. A method for constructing an electro-active sensor as set forth in Claim 53, wherein the method further comprises an act of forming a two-terminal temperature sensor on the second side of the nonconductive platform, thereby allowing for monitoring of a temperature of the electro-active sensor.

55. A method for constructing an electro-active sensor as set forth in Claim 36, wherein in the act of forming the second electrode set on the first side of the nonconductive platform, a second auxiliary electrode from the second electrode set is formed such that it is connected with the first auxiliary electrode from the first electrode set.

56. A method for constructing an electro-active sensor as set forth in Claim 55, wherein the first and second auxiliary electrodes are formed such that they are connected with a common ground.

57. A method for constructing an electro-active sensor as set forth in Claim 35, wherein the method for constructing an electro-active sensor further comprises an act of forming electrical connectors attached with the vias on the second side of the nonconductive platform, whereby the electrical connectors may be connected

with a monitoring apparatus, allowing for detection of the electro-active species in the solution.

58. A method for constructing an electro-active sensor as set forth in Claim 57, wherein in the act of forming electrical connectors attached with the vias on the second side of the nonconductive platform, the electrical connectors are formed such that they are substantially planar, with a plane of the electrical connectors being parallel with a plane of the nonconductive platform.

59. A method for constructing an electro-active sensor as set forth in Claim 57, wherein the act of forming electrical connectors attached with the vias comprises acts of:

depositing a conductive material on the second side of the nonconductive platform, such that the material is in contact with the vias;

curing the conductive material to affix the conductive material with both the second side of the nonconductive platform and with the vias.

60. A method for constructing an electro-active sensor as set forth in Claim 35, wherein the act of forming an electrode on the first side of the nonconductive platform further comprises acts of:

depositing a conductive material on the first side of the nonconductive platform; and

curing the electrically conductive material to affix the conductive material to the nonconductive platform.

61. A method for constructing an electro-active sensor as set forth in Claim 35, wherein the act of forming a via from the first side to the second side of the nonconductive platform further comprises acts of:

forming a via through the nonconductive platform from the first side to the second side of the nonconductive platform;

depositing a conductive material over the via;

creating an electrically conductive via by drawing the conductive material through the via; and

curing the electrically conductive material to affix the conductive material with the first side of the nonconductive platform, with the second side of the nonconductive platform, and with the walls of the via, thereby creating the via.

62. A method for constructing an electro-active sensor as set forth in Claim 35, wherein the act of forming an electrode on the first side of the nonconductive platform further comprises an act of selecting a non-conductive platform constructed of a material selected from a group consisting of ceramic and glass.

63. A method for constructing an electro-active sensor as set forth in Claim 35, wherein in the act of forming the first electrode set on the first side of the nonconductive platform, the electrodes are formed such that they are substantially planar.

64. A method for constructing an electro-active sensor as set forth in Claim 35, wherein in the acts of forming the electrode set, at least a portion of each electrode in the electrode set is formed in a shape from a group consisting of a ring and a disk.

65. A method for constructing an electro-active sensor as set forth in Claim 35, wherein in the acts of forming the electrode set, each electrode in the electrode set is formed such that the electrodes are concentric.

66. A method for constructing an electro-active sensor as set forth in Claim 35, wherein in the acts of forming the electrode set, the reference electrode is formed such that it surrounds the working electrode, and the auxiliary electrode is formed such that it surrounds the reference electrode.

67. A method for constructing an electro-active sensor as set forth in Claim 35, further comprising an act of attaching a biofilm on the first side of the nonconductive platform.

68. A method for constructing an electro-active sensor as set forth in Claim 35, further comprising an act of forming an Ion Selective Sensor on the first side of the nonconductive platform.

69. A method for constructing an electro-active sensor as set forth in Claim 35, wherein in the act of forming an Ion Selective Sensor on the first side of the nonconductive platform, the Ion Selective Sensor is a pH sensor.

70. A method for constructing an electro-active sensor as set forth in Claim 35, further comprising an act of forming a four-terminal conductivity sensor on the first side of the nonconductive platform, thereby allowing for measurement of conductivity of the solution.

71. A method for constructing an electro-active sensor as set forth in Claim 35, further comprising an act of forming two-terminal heater on the second side of the nonconductive platform, thereby allowing the electro-active sensor to be heated to varying temperatures.

72. A method for constructing an electro-active sensor as set forth in Claim 35, further comprising an act of forming a two-terminal temperature sensor on the second side of the nonconductive platform, thereby allowing for monitoring of a temperature of the electro-active sensor.

73. An electro-active species detection and observation apparatus, comprising:

a fluid-tight first sealable chamber for sealing at least a portion of an electro-active sensor within an interior of the sealable chamber, the electro-active sensor having electrodes on the portion of the electro-active sensor sealed within the interior of the sealable chamber;

a first inlet port connected with the first sealable chamber; and

a first outlet port connected with the first sealable chamber, whereby a solution may be introduced into the first sealable chamber through the first inlet port and exit through the first outlet port, thereby allowing for detection and measurement of an electro-active species within the solution be the electro-active sensor, as the solution flows through the first sealable chamber.

74. An electro-active species detection and observation apparatus as set forth in Claim 73, wherein the apparatus further comprises a first window attached with the first sealable chamber, thereby allowing for observation of the interior of the sealable chamber.

75. An electro-active species detection and observation apparatus as set forth in Claim 74, wherein the window is constructed such that it is compatible with an objective of a microscope.

76. An electro-active species detection and observation apparatus as set forth in Claim 75, wherein the apparatus further comprises a fluid spreader connected

with the inlet port, where the solution is introduced to the fluid spreader before being introduced to a remainder of the sealable chamber, thereby eliminating bubbles and allowing the solution to be uniformly spread.

77. An electro-active species detection and observation apparatus as set forth in Claim 76, wherein the apparatus further comprises a first O-ring and a second O-ring, the first O-ring and the second O-ring being detachably attachable with the sealable chamber, whereby the portion of the electro-active sensor having electrodes may be placed between the first O-ring and the second O-ring, thereby sealing a chamber with the top side of the electro-active sensor.

78. An electro-active species detection and observation apparatus as set forth in Claim 77, wherein the apparatus further comprises a monitoring apparatus with circuitry for attaching with the electro-active sensor, wherein the circuitry further comprises:

a potentiostat circuit portion for attaching with an electrochemical cell, the electrochemical cell comprising a grounded auxiliary electrode, a reference electrode, and working electrode, whereby the potentiostat circuit portion forces a voltage between the working electrode and the reference electrode;

a feedback circuit operable with the potentiostat circuit portion, whereby when the potentiostat circuit portion is activated, the feedback circuit adjusts a current though the electrochemical cell accordingly;

a galvanostat circuit portion for attaching attached with the electrochemical cell, whereby the galvanostat circuit portion forces a current through the electrochemical cell and when the galvanostat circuit portion is activated the feedback circuit adjusts a voltage between the working electrode and the reference electrode; and

a switch circuit connected with the potentiostat and galvanostat portion, allowing for the activation of the potentiostat or galvanostat circuit portion.

79. An electro-active species detection and observation apparatus as set forth in Claim 78, further comprising:

a fluid-tight second sealable chamber for sealing at least a portion of an electro-active sensor within an interior of the second sealable chamber, the electro-active sensor having electrodes;

a second inlet port connected with the second sealable chamber; and

a second outlet port connected with the second sealable chamber, whereby a solution may be introduced into the second sealable chamber through the second inlet port and exit through the second outlet port, thereby allowing utilization of both the first sealable chamber and the second sealable chamber to conduct multiple tests.

80. An electro-active species detection and observation apparatus as set forth in Claim 79, wherein the apparatus further comprises a second window attached with the second sealable chamber, thereby allowing for observation of an interior of the second sealable chamber.

81. An electro-active species detection and observation apparatus as set forth in Claim 80, wherein the apparatus further comprises:

a micro-fluidics system attached with both the first sealable chamber and the second sealable chamber, allowing for control of the solution applied to each chamber.

82. An electro-active species detection and observation apparatus as set forth in Claim 73, wherein the window is constructed such that it is compatible with an objective of a microscope.

83. An electro-active species detection and observation apparatus as set forth in Claim 73, wherein the apparatus further comprises a fluid spreader connected with the inlet port, where the solution is introduced to the fluid spreader before being introduced to a remainder of the sealable chamber, thereby eliminating bubbles and allowing the solution to be uniformly spread.

84. An electro-active species detection and observation apparatus as set forth in Claim 73, wherein the apparatus further comprises a first O-ring and a second O-ring, the first O-ring and the second O-ring being detachably attachable with the sealable chamber, whereby the portion of the electro-active sensor having electrodes may be placed between the first O-ring and the second O-ring, thereby sealing a chamber with the top side of the electro-active sensor.

85. An electro-active species detection and observation apparatus as set forth in Claim 73, wherein the apparatus further comprises a monitoring apparatus with circuitry for attaching with the electro-active sensor, wherein the circuitry further comprises:

a potentiostat circuit portion for attaching with an electrochemical cell, the electrochemical cell comprising a grounded auxiliary electrode, a reference electrode, and working electrode, whereby the potentiostat circuit portion forces a voltage between the working electrode and the reference electrode;

a feedback circuit operable with the potentiostat circuit portion, whereby when the potentiostat circuit portion is activated, the feedback circuit adjusts a current though the electrochemical cell accordingly;

a galvanostat circuit portion for attaching attached with the electrochemical cell, whereby the galvanostat circuit portion forces a current through the electrochemical cell and when the galvanostat circuit portion is activated the feedback circuit adjusts a voltage between the working electrode and the reference electrode; and

a switch circuit connected with the potentiostat and galvanostat portion, allowing for the activation of the potentiostat or galvanostat circuit portion.

86. An electro-active species detection and observation apparatus as set forth in Claim 73, further comprising:

a fluid-tight second sealable chamber for sealing at least a portion of an electro-active sensor within an interior of the second sealable chamber, the electro-active sensor having electrodes;

a second inlet port connected with the second sealable chamber; and

a second outlet port connected with the second sealable chamber, whereby a solution may be introduced into the second sealable chamber through the second inlet port and exit through the second outlet port, thereby allowing utilization of both the first sealable chamber and the second sealable chamber to conduct multiple tests.

87. An electro-active species detection and observation apparatus as set forth in Claim 86, wherein the apparatus further comprises a second window attached with the second sealable chamber, thereby allowing for observation of an interior of the second sealable chamber.

88. An electro-active species detection and observation apparatus as set forth in Claim 87, wherein the apparatus further comprises:

a micro-fluidics system attached with both the first sealable chamber and the second sealable chamber, allowing for control of the solution applied to each chamber.

89. A dual mode circuitry for attaching with an electrochemical cell, comprising:

a potentiostat circuit portion capable of being attached with an electrochemical cell, the electrochemical cell comprising a grounded auxiliary electrode, a reference electrode, and a working electrode, whereby the potentiostat circuit portion forces a voltage between the working electrode and the reference electrode;

a feedback circuit operable with the potentiostat circuit portion, whereby when the potentiostat circuit portion is activated, the feedback circuit adjusts a current though the electrochemical cell accordingly;

a galvanostat circuit portion capable of being attached with the electrochemical cell, whereby the galvanostat circuit portion forces a current through the electrochemical cell and when the galvanostat circuit portion is activated, the feedback circuit adjusts a voltage between the working electrode and the reference electrode; and

a switch circuit connected with the potentiostat and galvanostat portion, allowing for the activation of the potentiostat or galvanostat circuit portion.

90. The circuitry of Claim 89, wherein the potentiostat circuit portion further comprises a first instrumentation amplifier having a first input, a second input and an output, with the first input connected with the reference electrode, the second input connected with the working electrode, and the output connected with the switch circuit.

91. The circuitry of Claim 90, wherein the galvanostat circuit portion further comprises a second instrumentation amplifier having a first input, a second input and an output, and at least one resistor, with the first input connected to the working electrode, the second input connected with the working electrode through the at least one resistor, and the output is connected with the switch circuit.

92. The circuitry of claim 91, wherein the feedback circuit further comprises an operational amplifier having a first input, a second input and an output, with the first input connected with an output of the switch circuit, the second input connected with a digital to analog converter, and the output connected with the working electrode.

93. The circuitry of Claim 89, wherein the galvanostat circuit portion further comprises a second instrumentation amplifier having a first input, a second input and an output, and at least one resistor, with the first input connected to the working electrode, the second input connected with the working electrode through the at least one resistor, and the output is connected with the switch circuit.

94. The circuitry of claim 89, wherein the feedback circuit further comprises an operational amplifier having a first input, a second input and an output, with the first input connected with an output of the switch circuit, the second input connected with a digital to analog converter, and the output connected with the working electrode.